



The Evolvable Mars Campaign – Study Status

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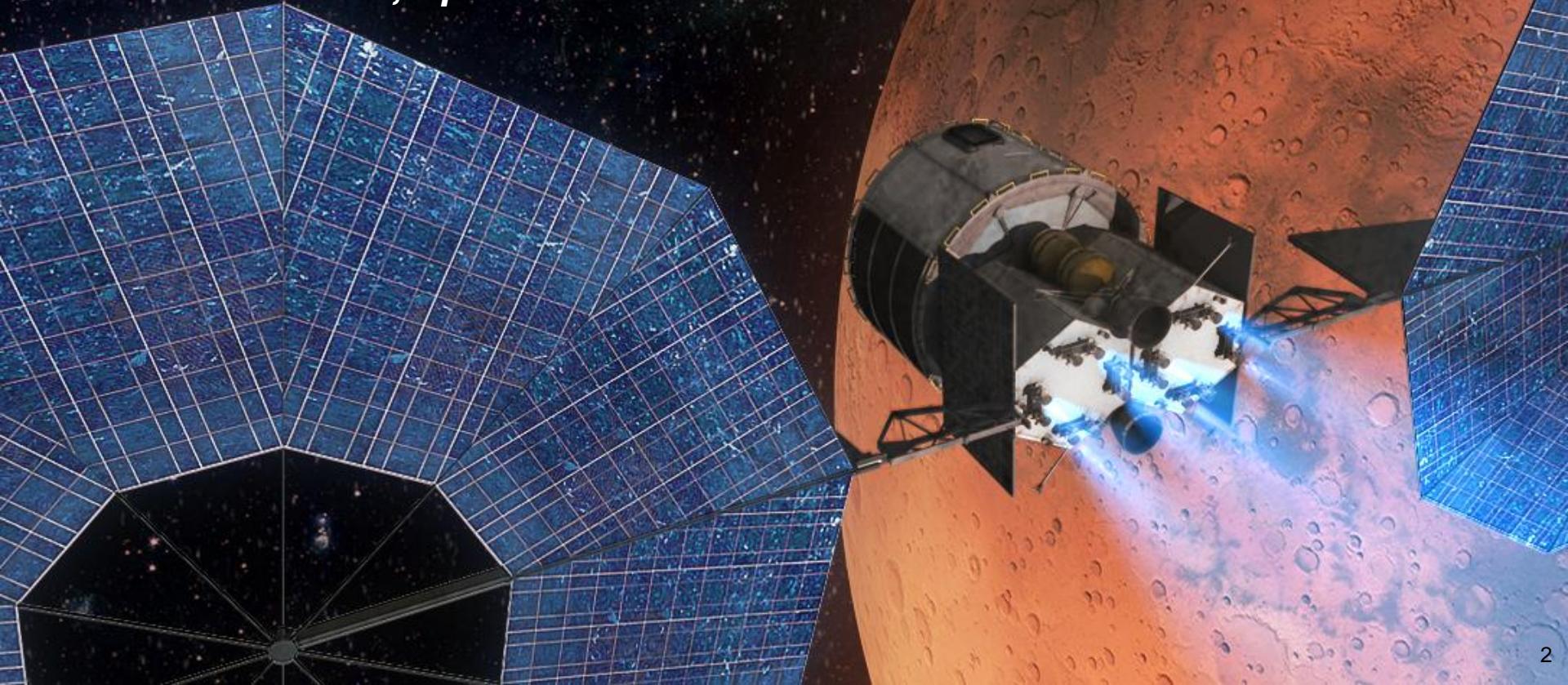


Pioneering Space - Goals



“Fifty years after the creation of NASA, our goal is no longer just a destination to reach. Our goal is the capacity for people to work and learn and operate and live safely beyond the Earth for extended periods of time, ultimately in ways that are more sustainable and even indefinite. And in fulfilling this task, we will not only extend humanity’s reach in space -- we will strengthen America’s leadership here on Earth.”

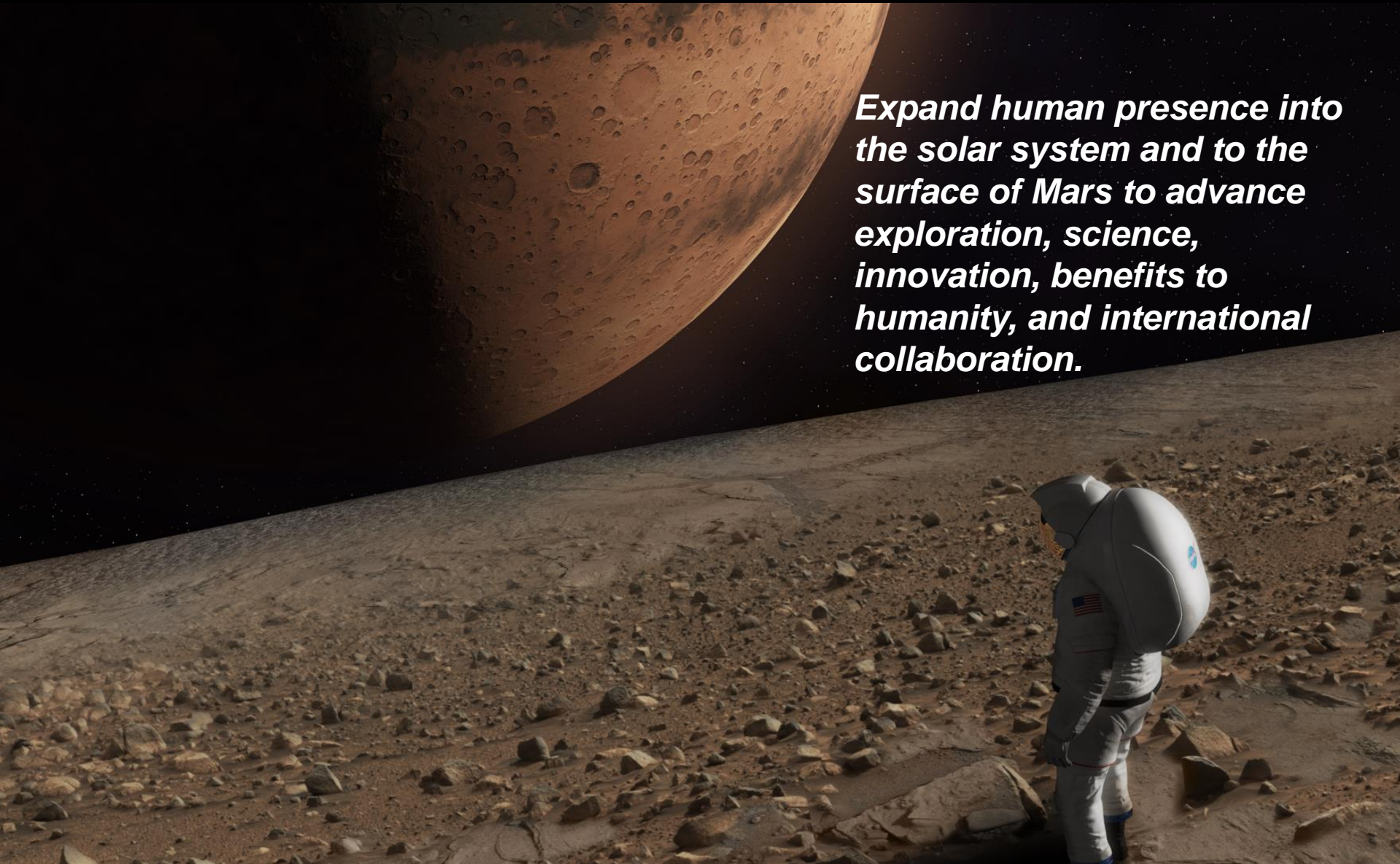
- President Obama, April 2010



NASA Strategic Plan Objective 1.1



Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity, and international collaboration.





Strategic Principles for Sustainable Exploration

- Implementable in the ***near-term with the buying power of current budgets*** and in the longer term with budgets commensurate with economic growth;
- ***Exploration enables science and science enables exploration, leveraging robotic expertise for human exploration of the solar system***
- Application of ***high Technology Readiness Level*** (TRL) technologies for near term missions, while focusing sustained investments on ***technologies and capabilities*** to address challenges of future missions;
- ***Near-term mission opportunities*** with a defined cadence of compelling and integrated human and robotic missions providing for an incremental buildup of capabilities for more complex missions over time;
- Opportunities for ***U.S. commercial business*** to further enhance the experience and business base;
- ***Multi-use, evolvable*** space infrastructure, minimizing unique major developments, with each mission leaving something behind to support subsequent missions; and
- Substantial ***international and commercial participation***, leveraging current International Space Station and other partnerships.

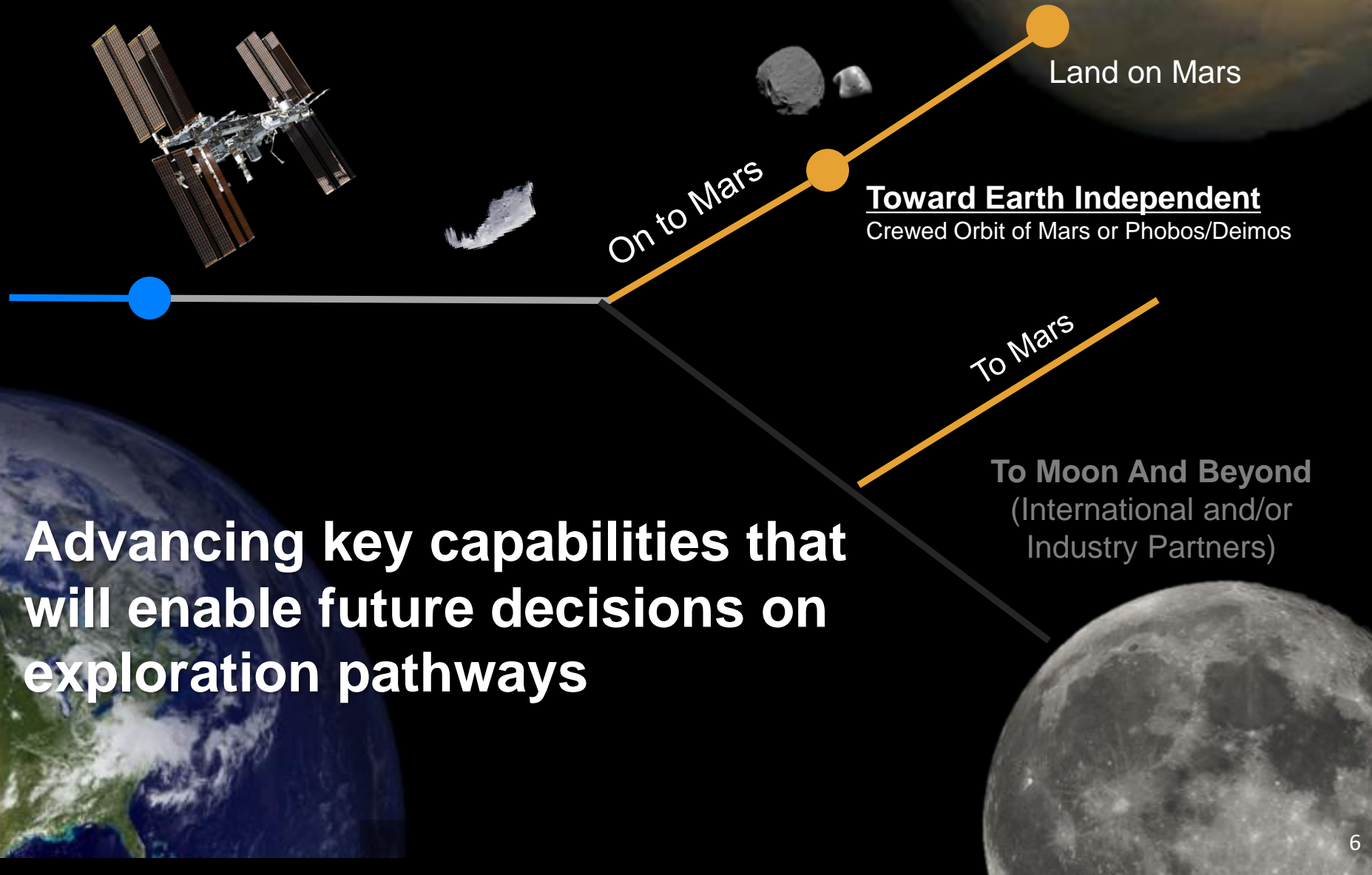


**EARTH
RELIANT**

**PROVING
GROUND**

**EARTH
INDEPENDENT**

Human Exploration Pathways



Evolvable Mars Campaign

EMC Goal: Define a pioneering strategy and operational capabilities that can extend and sustain human presence in the solar system including a human journey to explore the Mars system starting in the mid-2030s.

- **Identify a plan that:**

- Expands human presence into the solar system to advance exploration, science, innovation, benefits to humanity, and international collaboration.
- Provides different future scenario options for a range of capability needs to be used as guidelines for near term activities and investments
 - In accordance with key strategic principles
 - Takes advantage of capability advancements
 - Leverages new scientific findings
 - Flexible to policy changes
- Identifies linkages to and leverage current investments in ISS, SLS, Orion, ARM, EAM, technology development investments, science activities
- Emphasizes prepositioning and reuse/repurposing of systems when it makes sense
 - Use location(s) in cis-lunar space for aggregation and refurbishment of systems

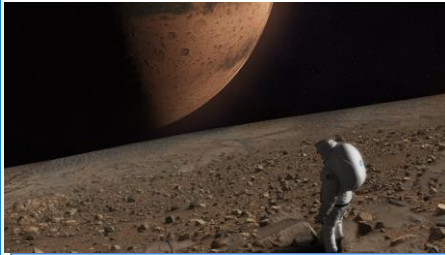
Internal analysis team members:

- ARC, GRC, GSFC, HQ, JPL, JSC, KSC, LaRC and MSFC
- HEOMD, SMD, STMD, OCS, and OCT

External inputs from:

- International partners, industry, academia, SKG analysis groups

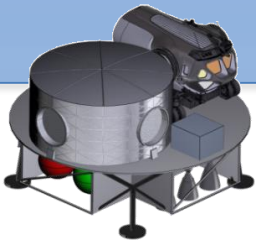
Evolvable Mars Campaign Studies in FY14 - Pointing the Way Forward



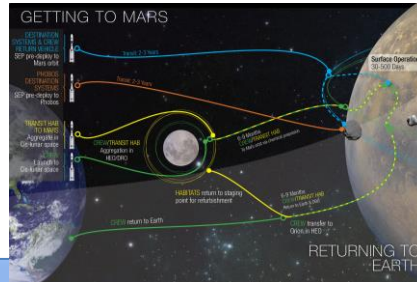
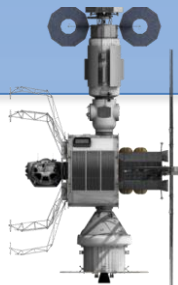
**Mars and Mars Moons
Surface Exploration**



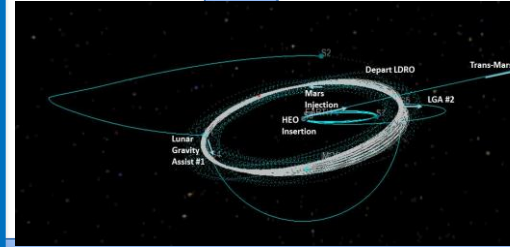
**Human Class Mars
Surface Lander**



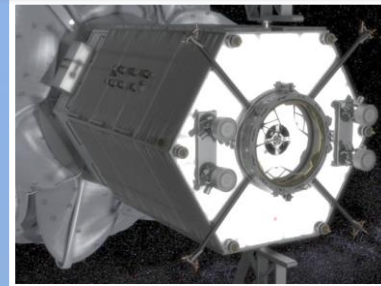
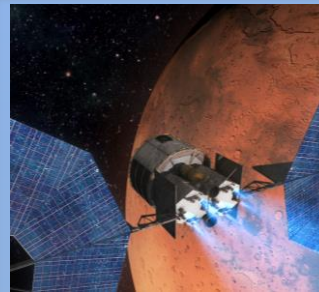
**Mars Campaign
Habitation**



Transportation Analysis



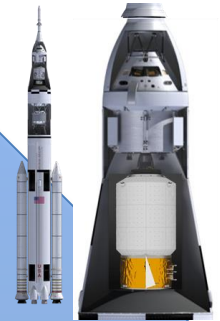
Staging Point Location



SEP

ARM Extensibility

Deep Space Surface Operations in micro-g



**SLS Exploration
Upperstage and
Co-Manifested
Cargo**



**Capability
Development Analysis**



EMC Expansion of Capabilities

Informed by NASA Technology Roadmaps, System Maturation Teams, Partners and External Experts

Earth Reliant

- International Space Station: **Can humans live & operate independently for ~1000 days in micro-G?**
 - Long-duration, Zero-g human factors research platform
 - Highly reliable life support, advanced logistics, low maintenance systems
 - Environmental monitoring
 - Supportability & maintenance concepts



Earth Independent - Phobos/Deimos/Mars Orbit

- Can humans travel to Mars orbit and safely return to Earth?
- Deep Space Proving Ground plus:
 - High power SEP
 - ~1000 day deep space habitat(s)
 - Deep space countermeasures
 - Mars vicinity propulsion

Earth Independent – Mars Surface

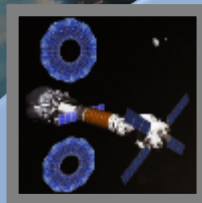
- Phobos/Deimos plus:
 - Mars entry & landing systems
 - Partial-gravity countermeasures
 - Long duration surface Systems (ISRU, fission power)



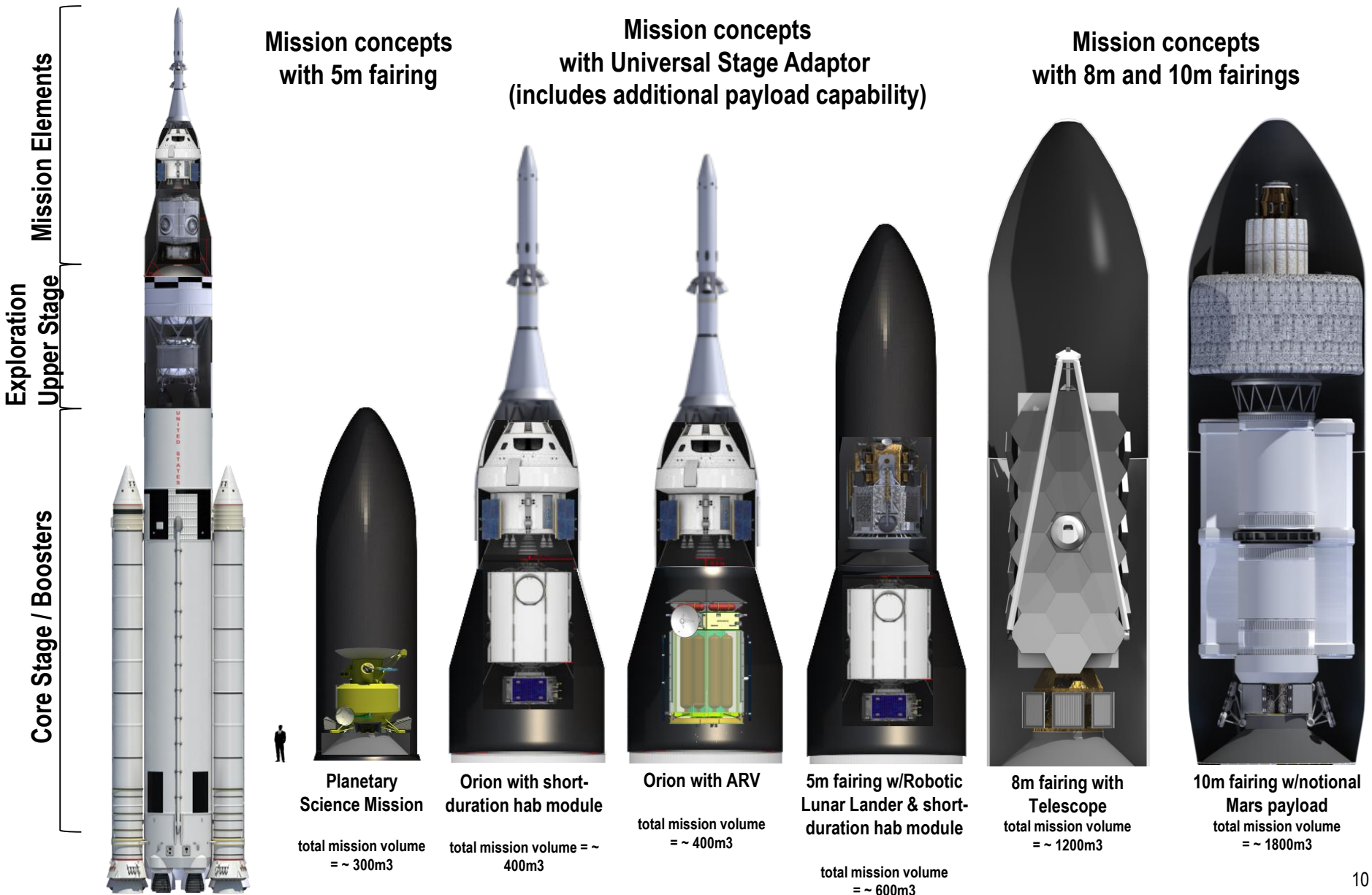
Continued Leveraging of Commercial & International Partnerships

Deep Space Proving Ground

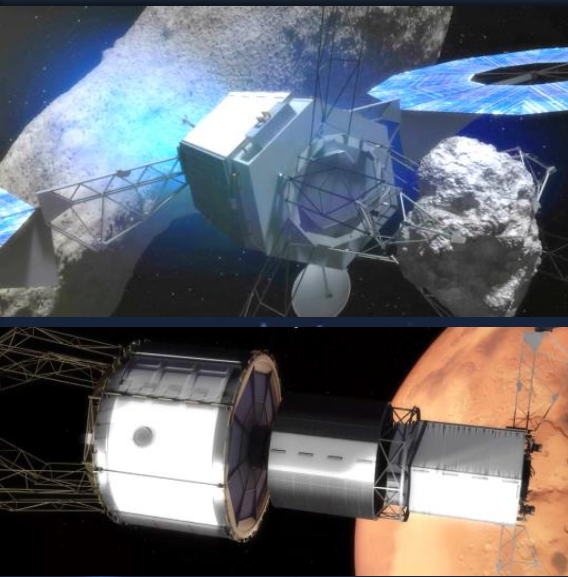
- Bridging from ISS, can human class systems operate in a deep space environment in a crew tended mode for long durations?
- Distant Retrograde Orbit
- Heavy lift launch (SLS), Orion
- High-power In-Space Propulsion
- Exploration Augmentation Module - Crew support for increasing duration (habitat)
- Advanced EVA (Suit, PLSS)
- Deep space long duration systems and operations testing
- Aggregation of Mars Mission Vehicles



EUS & Payload Accommodation Options



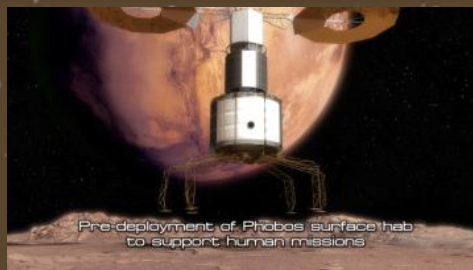
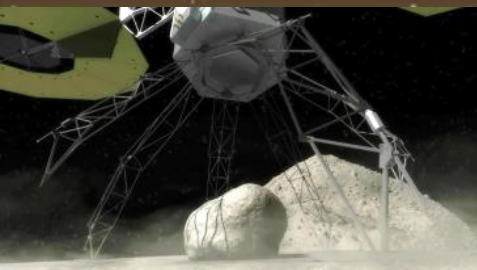
ARM Risk Reduction for Future Mars & Deep Space Missions



Long duration **human-scale systems** operating in deep space. Pre-deployment of crewed mission elements via solar electric propulsion with long quiescent periods.



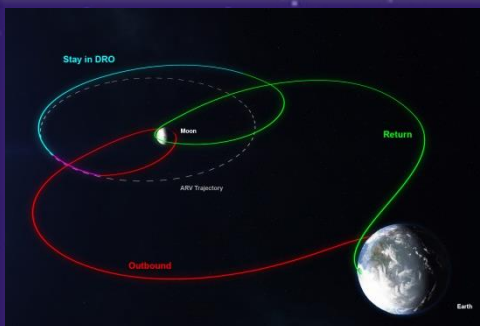
Sensor suites and proximity operations required for aggregating Mars mission vehicle stacks, deep space rendezvous and docking with Orion.



Enhanced interaction with **uncooperative, low-G targets** as will be experienced with Mars Moons.



In-space EVA ops and on micro-g body (Phobos), sample handling, and ISRU.



Mission Operations: Deep space trajectories, rendezvous and docking, pre-deployment of systems.



Long duration, high-power **Solar Electric Propulsion:** Solar arrays, thrusters, PMAD, Xenon storage.

Near Term Proving Ground Future Mission Candidates



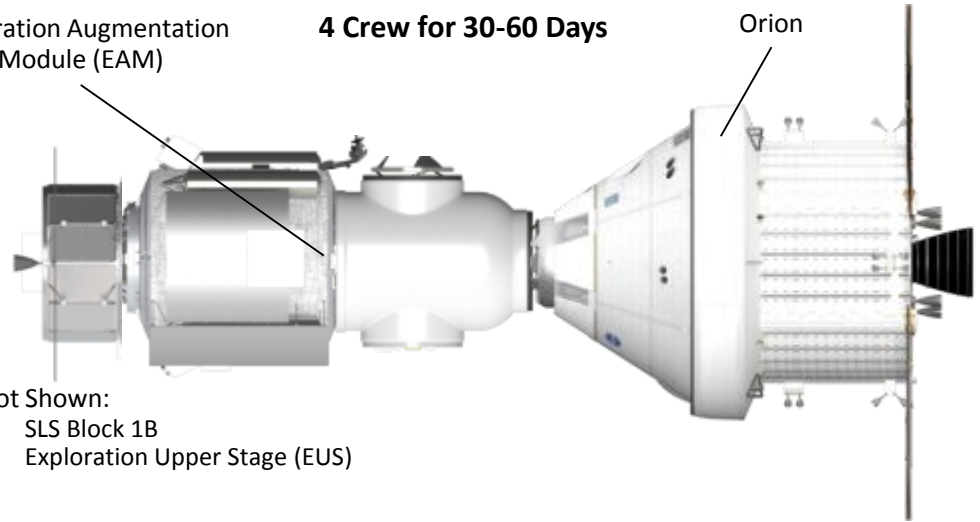
Delivery of Early
Habitation/Exploration
Augmentation Module

Exploration Augmentation
Module (EAM)

4 Crew for 30-60 Days

Orion

Not Shown:
SLS Block 1B
Exploration Upper Stage (EUS)



**Asteroid Redirect Crewed
Utilization Mission**



4 Crew for 60 - 120 Days

Not Shown:
SLS Block 1B
Exploration Upper Stage (EUS)
Orion
Asteroid Robotic Vehicle (ARV)
Evolvables Deep Space Habitat (EDSH)
Logistics Resupply Module



Potential Mars Human Landing Sites

- Identify human Mars exploration and science objectives and identify potential Mars landing sites.

Mars 2020

- Demonstrate ISRU, dust characterization, and potential ground truth of human mission landing site.

Mars Moon Prospector

- Demonstrate mobility, prospecting, and science capabilities through geological surveys of Phobos and Deimos to support infrastructure for characterizing gravitational fields, scientific regions of interest, soils mechanics, and useful resource materials.

Mars Surface Access Pathfinder

- Demonstrate human relevant scale aerocapture, aeroentry, descent, & landing. Opportunities for demonstration of surface power and larger scale ISRU which could lead to alternate sample return strategies.

Lunar Resource Prospector

- Demonstrate ISRU acquisition and processing on lunar surface to produce oxygen.

Working with SMD and STMD on mission studies in FY15

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A composite space image featuring the Earth, the Moon, Mars, and several asteroids against a starry background. The Earth is in the bottom left, showing blue oceans and white clouds. The Moon is in the top left, showing its grey, cratered surface. Mars is in the top right, showing its reddish-brown surface with polar ice caps. Several asteroids of various sizes and shapes are scattered throughout the scene, particularly in the bottom right. The background is a deep black space filled with numerous stars and some nebulae.

**Pursuing a Pioneering Space strategy
to meet national space policy goals
guided by our strategic principles**